

# Influence of caffeine in para- and tetraplegic participants in a 3min all-out arm crank ergometer test



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# Introduction

**Table 1.** Caffeine content of common foods, drinks, and nonprescription preparations.

Food or drink	Serving	Caffeine, mg*
Instant coffee	250 mL (8 oz) cup	60 (12–169) <sup>†</sup>
Brewed coffee	250 mL (8 oz) cup	80 (40–110) <sup>†</sup>
Short black coffee or espresso	1 standard serving	107 (25–214) <sup>†</sup>
Starbucks Breakfast Blend brewed coffee (Venti size)	600 mL (20 oz)	415 (300–564) <sup>§</sup>
Iced coffee (commercial brands)	500 mL bottle (16 oz)	30–200
Frappuccino	375 mL (12 oz) cup	90
Tea	250 mL (8 oz) cup	27 (9–51) <sup>†</sup>
Iced tea	600 mL (20 oz) bottle	20–40
Hot chocolate	250 mL (8 oz) cup	5–10
Chocolate milk	60 g	5–15
Dark chocolate	60 g	10–50
Viking chocolate bar	60 g	58
Coca-Cola	375 mL (12 oz) can	49
Pepsi cola	375 mL (12 oz) can	40
Jolt soft drink	375 mL (12 oz) can	75
Red Bull energy drink	250 mL (8 oz) can	80
Red Eye Power energy drink	250 mL (8 oz) can	50

Burke LM, Caffeine and sports performance, Appl. Physiol. Nutr. Metab. 33: 1319 – 1334 (2008)

# Caffeine acting as a stimulant

- Several different targets: adenosine receptors, inhibition of phosphodiesterase, calcium channel (RyR), GABA<sub>A</sub> receptors
  - Increased epinephrine and norepinephrine concentrations
  - Fighting «fatigue»
  - Bronchodilatation
  - Increased heart rate
  - Regulation of myocardial blood flow
  - Increased alertness, concentration and reaction
  - Increased contractile function (calcium release)
- **Activation of sympathetic nervous system!**



# Caffeine and sports performance

- **Ergogenic supplement** (rowing, swimming, running, cycling, etc.) in able-bodied subjects (Burke, 2008; Tarnopolsky, 2008)
- Studies showed ergogenic effects in short-term, high-intensity exercise between 1 to 10min (Wiles et al., 1992; Wiles et al., 2006; Bruce et al., 2000, Anderson et al., 2000, etc.)
- At this time, only one study (Flueck et al., 2014)
  - No benefit over 1500m in elite wheelchair athletes
  - Future studies in spinal cord injured athletes are needed

# Aim of the Study

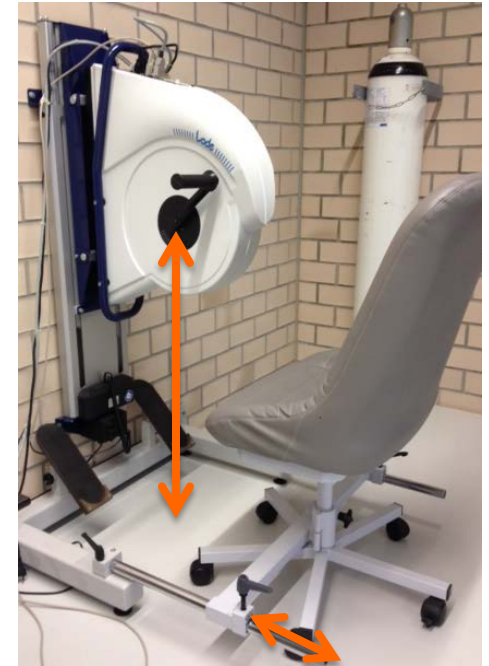
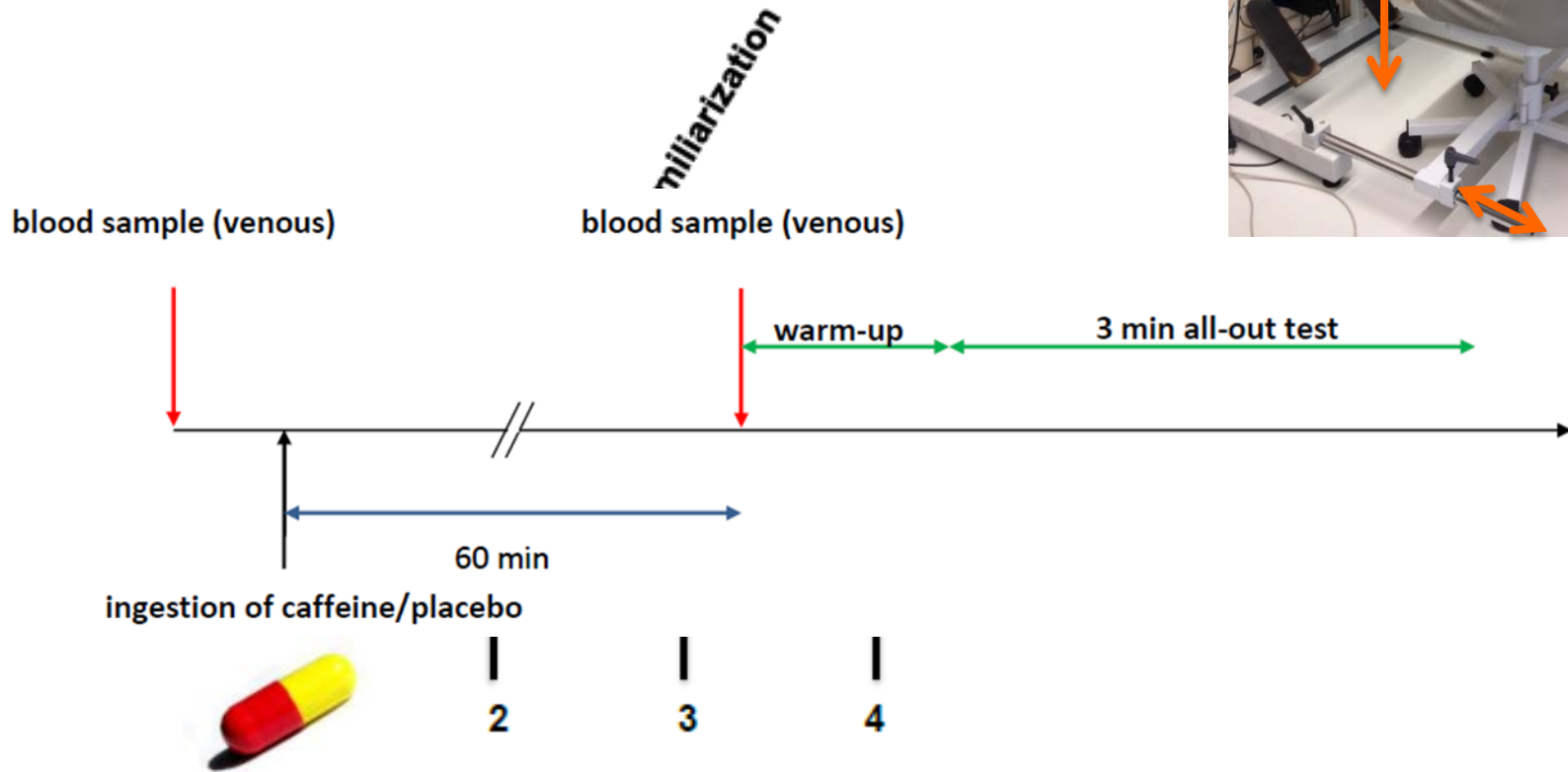
→ Influence of caffeine on 3min performance in spinal cord injured subjects compared to able-bodied

## Hypothesis:

- *Paraplegic and able-bodied:*
  - Increased catecholamines
  - Increased performance through caffeine
- *Tetraplegic:*
  - No increase in catecholamines
  - No increase in performance

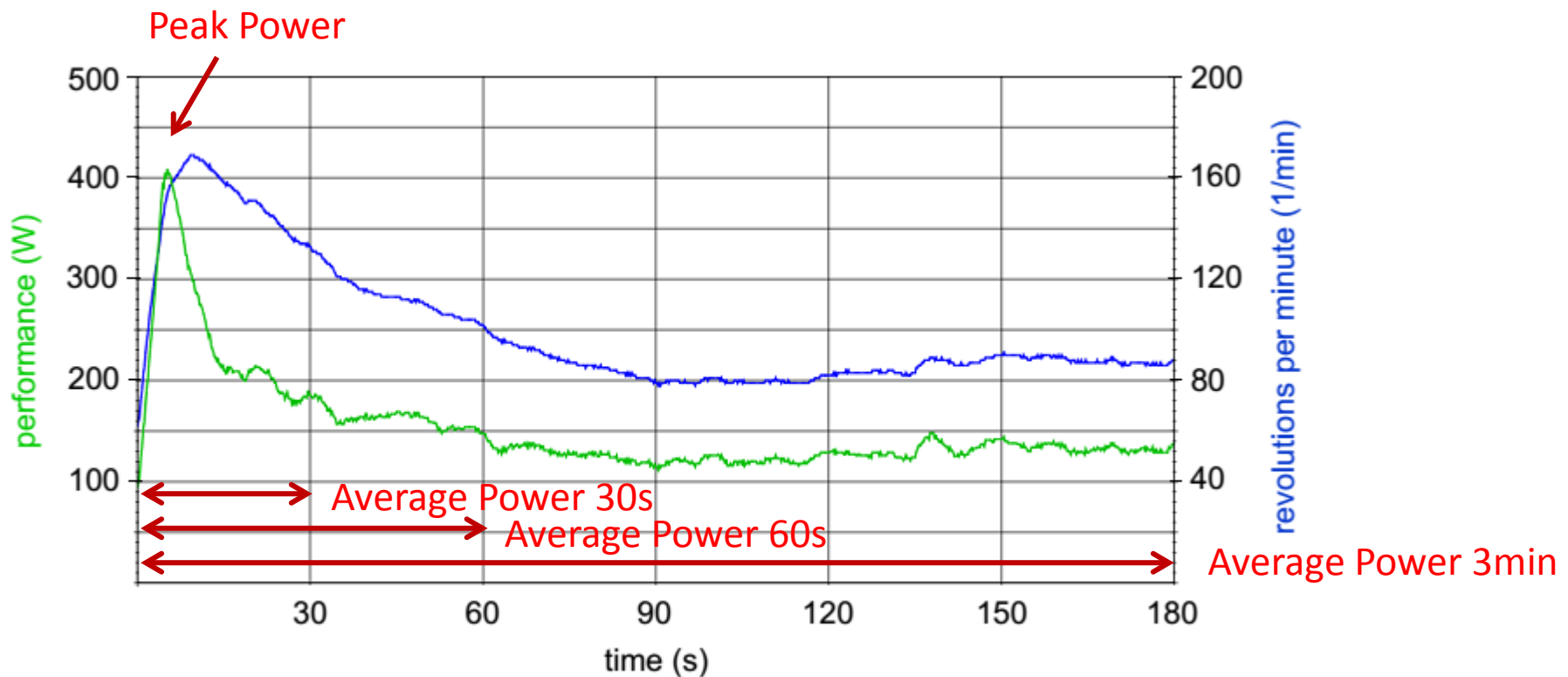
# Study Design

Randomized, placebo-controlled, doubleblind



# 3min all-out Test Arm Crank Ergometer

Example able-bodied subject:



Flueck JL et al. 2015, **Reliability of a 3min all-out arm crank ergometer exercise test**, *Int J Sport Med*, 36: 809-813

# Results: Study Participants

- **17 able-bodied:** Age 38 y [25; 52];  
Height 183cm [172; 193];  
Body mass 79kg [67; 95];  
 $VO_{2peak}$  39.9ml/min/kg [23.6; 57.6]
- **10 paraplegic:** Age 43.5 y [22; 59];  
Height 177cm [150; 185];  
Body mass 74.5kg [63; 80];  
 $VO_{2peak}$  34.4ml/min/kg [19.5; 48.8]
- **7 tetraplegic:** Age 40 y [24; 65];  
Height 180cm [168; 190];  
Weight 75kg [60; 85];  
 $VO_{2peak}$  13.6ml/min/kg [8.6; 16.3]



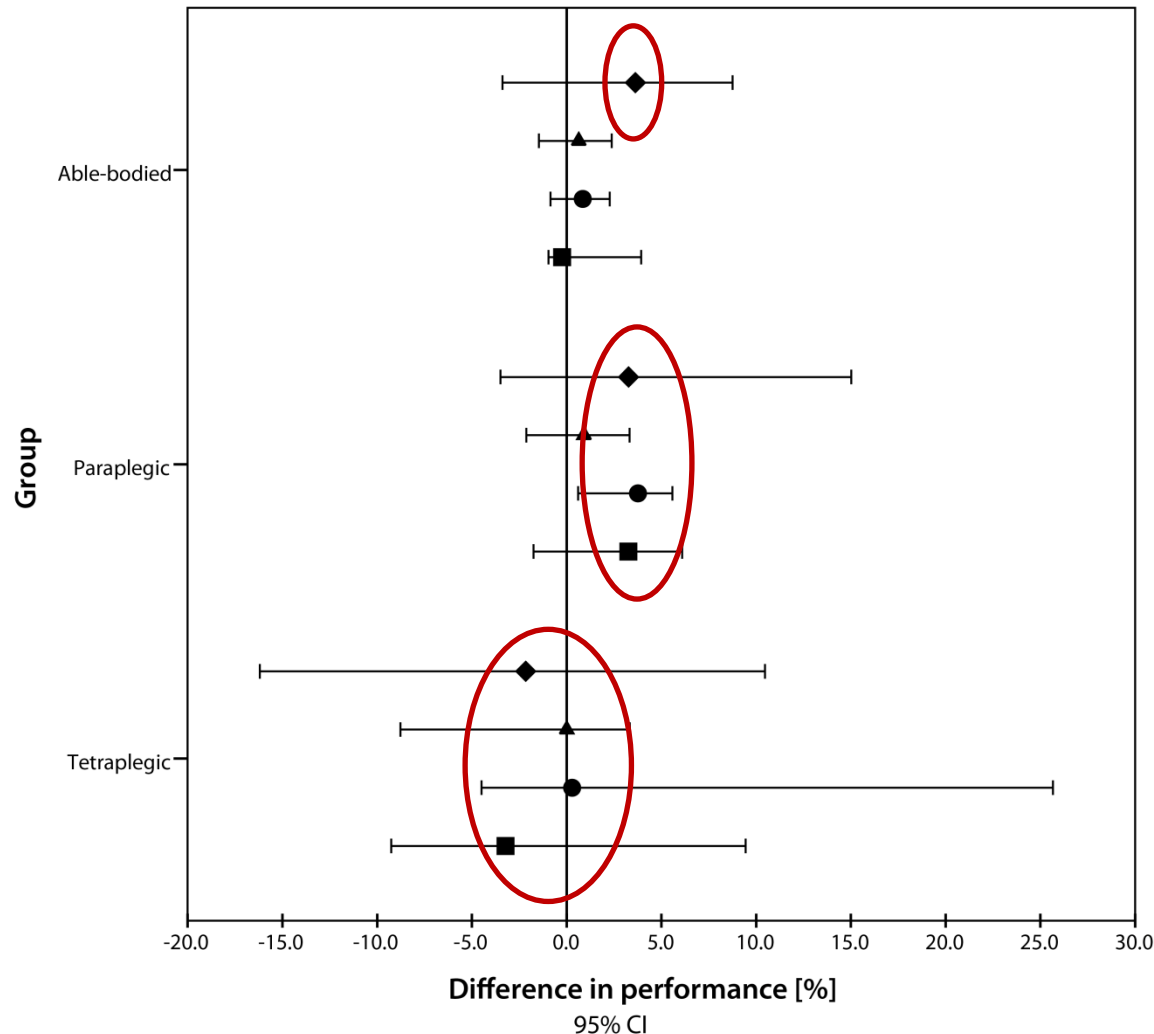


# Results: Power Output

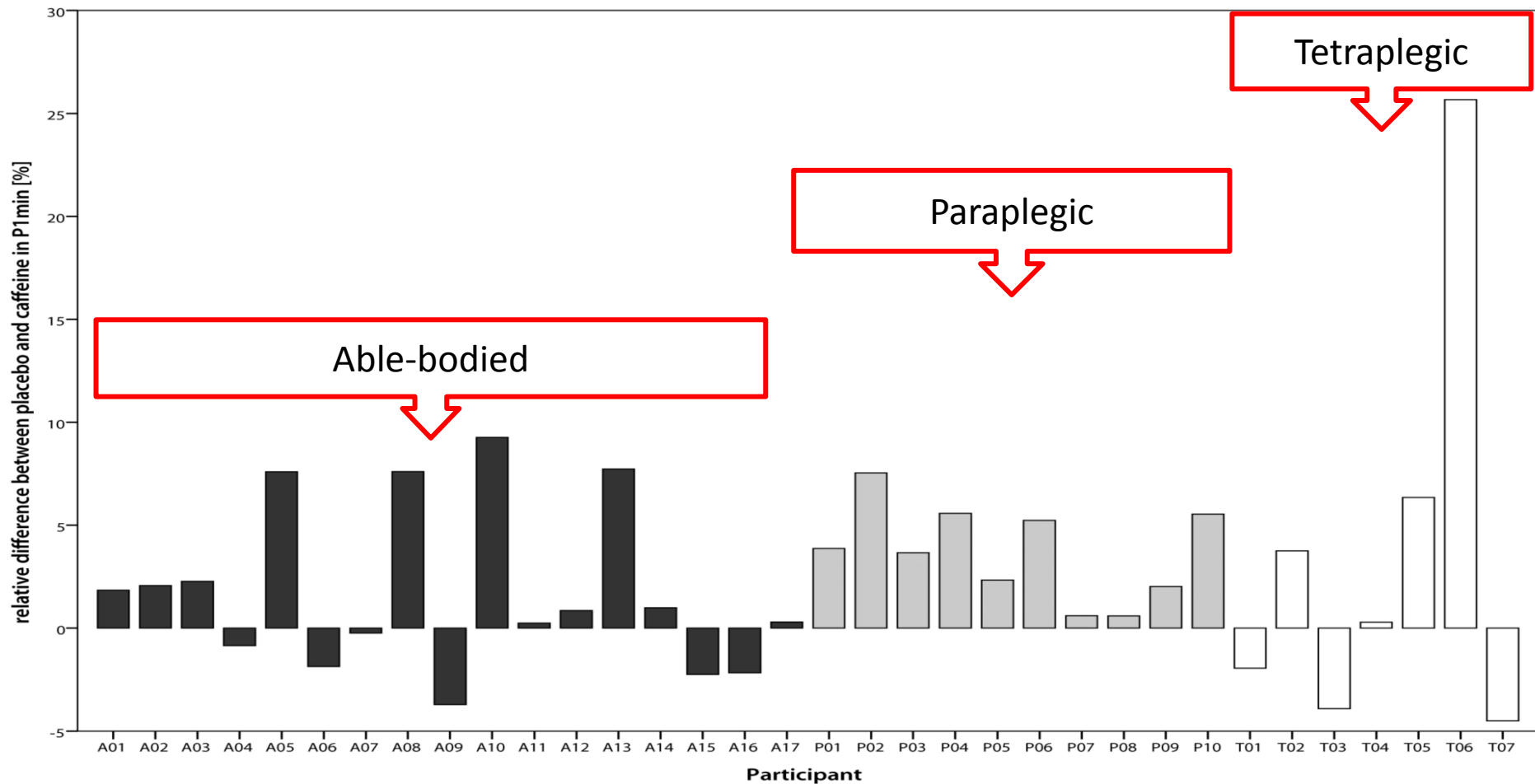
Parameter	Participants	Placebo		Caffeine	p-value
<b>P<sub>Peak</sub> (W)</b>	Able-bodied	468 [341; 679]	+46W →	514 [309; 656]	0.102
	Paraplegic	377 [173; 516]	+21W →	397.5 [159; 513]	0.169
	Tetraplegic	86 [45; 182]		88 [42; 161]	0.491
<b>P<sub>3min</sub> (W)</b>	Able-bodied	174 [139; 212]		172 [141; 203]	0.887
	Paraplegic	161 [91; 181]		162.5 [95; 187]	0.539
	Tetraplegic	42 [14; 57]		41 [14; 52]	0.197
<b>P<sub>1min</sub> (W)</b>	Able-bodied	220 [187; 268]		231 [189; 277]	0.246
	Paraplegic	208 [123; 237]		214 [123 ; 253]*	<b>0.005</b>
	Tetraplegic	62 [17; 84]		61 [21; 81]	0.866
<b>P<sub>30s</sub> (W)</b>	Able-bodied	270 [230; 315]		272 [230; 321]	0.435
	Paraplegic	242 [138; 278]		249 [131; 291.]*	<b>0.028</b>
	Tetraplegic	68 [30; 106]		70 [28; 100]	0.612
<b>FI (W/s)</b>	Able-bodied	1.9 [1.4; 3.1]		2.2 [1.3; 3.1]*	<b>0.045</b>
	Paraplegic	1.5 [0.6; 2.3]		1.6 [0.5; 2.2]	0.478
	Tetraplegic	0.3 [0.2; 0.9]		0.4 [0.2; 0.8]	0.564

# Results: Power Output Compared to Placebo

- ◆ Peak Power
- ▲ Average Power 3min
- Average Power 60s
- Average Power 30s



# Results: Individual Power Output



# Results: Blood Parameters

Plasma concentrations	Group	PLACEBO		CAFFEINE	
		Baseline	1 h post-ingestion	Baseline	1 h post-ingestion
Plasma caffeine [ $\mu\text{mol/L}$ ]	Able-bodied	1.3 [0.9; 14.2]	1.1 [0.9; 12.8]	1.9 [0.9; 11.8]	45.1 [36.9; 58.9]* § ‡
	Paraplegic	4.2 [0.9; 22.5]	3.8 [0.9; 19.1]	4.1 [0.9; 22.4]	54.0 [30.5; 85.3]* §
	Tetraplegic	0.9 [0.9; 6.1]	0.9 [0.9; 5.3]	0.9 [0.9; 13.8]	66.1 [53.7; 73.7]* §
Plasma epinephrine [nM]	Able-bodied	0.13 [0.04; 0.29]	0.11 [0.07; 0.22]	0.11 [0.07; 0.22]	0.29 [0.19; 0.41]*
	Paraplegic	0.08 [0.04; 0.26]	0.11 [0.08; 0.24]	0.09 [0.04; 0.67]	0.17 [0.06; 0.76]
	Tetraplegic	0.05 [0.04; 0.16]	0.04 [0.02; 0.10]	0.04 [0.02; 0.10]	0.05 [0.02; 0.13]
Plasma norepinephrine [nM]	Able-bodied	1.88 [0.96; 2.91] ‡	1.72 [1.05; 6.49]	1.74 [0.89; 2.96]	2.00 [0.75; 3.53]
	Paraplegic	2.32 [0.76; 3.59] ‡	2.26 [0.89; 4.42]	2.35 [1.14; 4.51]	3.06 [1.12; 5.63]
	Tetraplegic	0.34 [0.08; 0.71]	0.39 [0.18; 0.58]	0.29 [0.20; 0.76]	0.34 [0.12; 0.62]

# Discussion

- **Why a benefit in paraplegic but not in able-bodied subjects?**
  - Muscle fiber type distribution (Schantz et al., 1997)
  - Paraplegic more type I muscle fibers
  - Caffeine more sensitive to type I muscle fibers (Mitsumoto et al., 1990)
- **Why no benefit in tetraplegic subjects?**
  - Less active muscle mass
  - Less to no sympathetic activation
  - No increase in plasma catecholamines
  - Big difference in performance between the subjects; very high intra-individual variability!

# Take Home Message

- No ergogenic effects over 3 min in all 3 groups
- Peak power not significantly increased in able-bodied and paraplegic subjects (clinically relevant??)
- Caffeine significantly increased power over the first 30 and 60s in paraplegic subjects (→200m, 400m, basketball, etc.)
- No benefit for tetraplegic subjects
- 4-6mg/kg body mass; 1h before the performance task

**→ Test the supplement individually in every athlete!!!**

# Thank you for the attention!!

